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ABSTRACT

This paper presents the thesis that information gained from the extensive research on conservation training can be utilized in planning curriculum content and teaching strategies, especially in concept acquisition. It is suggested that precise teaching techniques have been created and evaluated in studies of conservation training, and that every curriculum concept can be analyzed as a conservation concept by distinguishing relevant and irrelevant attributes. The child's understanding can then be tested by probing his or her ability to separate these two classes of attributes. Subsequent training would involve use of previously evaluated procedures for providing information and/or problem solving skills for segregating and integrating the relevant and irrelevant attributes. The general conservation training paradigm is presented, as are eight training procedures based on research. Possibilities for extended applications are discussed. (BD)

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Teaching Strategies and Conservation Training

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Between 1961 and 1976 about 140 research studies were published which were designed specifically in one way or another to train young children between four and seven years old to conserve. Seventy percent of these studies appeared between 1970 and 1975, and with only two percent of them appearing in 1976, it would appear that the conservation training preoccupation of developmental psychologists may have ended. Quite apart from the theoretical reasons which may have motivated and legitimized the attention scientific journals gave to this issue, the thesis of this paper is that in these studies a number of precise teaching techniques were created and more importantly were evaluated. Moreover, the extensive experimental literature on conservation, of which the training literature is a small part, provides serendipitously a model for programmatic research in educational psychology. From its inception at the turn of the century, educational psychology was planned as the discipline of the psychology of the various subject matters in which variables which predicted and controlled the acquisition of subject matter would be charted and explained. The claim that teaching could be a science was to be based upon this

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new discipline. For various reasons, the discipline wandered in the following decades from this central purpose; but the developmental psychologists have, perhaps unwittingly, followed the program faithfully in their evaluation of the conservation phenomenon.

While conservation researchers have limited themselves generally to the concepts Piaget researched originally (e.g., number amount, length, area, weight, time, volume, etc.), this limitation has been self-imposed, because the conservation paradigm can be applied without exception to any concept. When it is, it provides a diagnostic technique for measuring a person's understanding of a concept that is as old as Platonic dialectic in which various concepts like justice, virtue, goodness, etc. were each subjected to a series of relevant and irrelevant transformations by which their essences were finally apprehended. The point is that there is nothing in principle to distinguish the traditionally researched conservation concept from any other which might be of interest to the curriculum developer. It has been claimed by Piaget (1968) that conservation is reserved for quantitative and not qualitative concepts, but this claim must give way to the child's, not the researcher's, notion of a quantitative concept. The concept of substance or mass may be quantitative for the physicist, but it is difficult to be convinced that it is for children (and many adults) and yet it is conserved by children about seven years of age. Moreover, Saltz and

Hamilton (1968) have shown that conservation of qualitative concepts follows the same patterns that Piaget and others have claimed for quantitative concepts. Quite simply, every concept comprises a set of relevant attributes which define it. Sets of irrelevant attributes which the concept excludes are often correlated and associated with the relevant attributes. When they are, they make concept acquisition more difficult (Bourne, 1966). When they vary, subjects may assume the relevant attributes have varied also, in which case the concept will not be conserved since a change in an irrelevant attribute has been taken by the subject to be a change in a relevant one. Under these conditions even adults may fail to conserve rather simple concepts of numerical equivalence which prove no difficulty to children (Odom, Astor and Cunningham, 1975).

Also, researchers have restricted themselves generally to the types of transformations used by Piaget and his colleagues (viz., shape and position). When this limitation, too, has been discarded, it becomes possible to chart other important and unsuspected--yet arresting--errors in children's thinking (e.g., fathers that are drunks are no longer fathers, Saltz and Hamilton, 1963; or that making a clay ball colder makes it heavier, and warmer makes it lighter, Murray and Johnson, 1975). In this regard, incidentally, it seems that the connotations of the concept to be conserved are excellent candidates as the labels for seductive transformations. For

example, heavy connotes large, rough, strong, hard, etc. on the semantic differential, and changes in an object's size, texture, hardness are judged by second graders to change its weight also (Mummedal and Murray, 1969; Murray and Johnson, 1975).

Similarly, limitations in the type of material used as an exemplar of a concept can be extended beyond the usual clay balls and poker chips used by the Genevans with the result that an even finer map of the child's concept may be had as the basis for curriculum and instructional planning (e.g., the weight of objects and the weight of oneself under analogous transformations are not uniformly appreciated by young children, Murray, 1969).

Since the conservation research has proceeded vigorously for 16 years, a number of otherwise troublesome assessment questions that ordinarily plagued educational testing have been resolved for the paradigm, at least in the sense that sources of error are known. A set of inherently theoretical criterion questions remain, however. Various question formats, verbal and nonverbal procedures, and unobtrusive techniques exist (Murray, 1968 and 1970), and some have been standardized (e.g., Goldschmid & Bentler, 1968); and this has lead to more precise evaluation of concept attainment. Moreover, the influence of variables like SES, IQ (MA), sex, cognitive style, cultural milieu, degree of prior schooling, etc. have been researched with the overwhelming result that

the primary variable in explaining and predicting conservation variation is the child's mental age.

A number of reviews of the conservation training literature exist (e.g., Beilin, 1971 and in press; Brainerd, 1973; Brainerd and Allen, 1971; Glaser and Resnick, 1972; Goldschmidt, 1971; Peill, 1975; and Strauss, 1972, 1974/75). Because Piagetian theory had claimed that conceptual development was under the sufficient control of unique and largely unmodifiable structural mechanisms, the intent of the early studies was to demonstrate that conservation could be trained and was amenable to conventional learning procedures. The failure of the first dozen training attempts (Flavell, 1963) undoubtedly motivated the subsequent attempts with the result that there is no longer doubt that conservation can be taught (e.g., Beilin, in press). Still there is an overwhelming and somewhat pessimistic result that training--even highly individualized training--is only successful (by whatever criteria) with about half the children in the sample, or more precisely that the children make about half the gains in conservation performance that could be made, although the gains are stable for as long as a month and are significantly different from pretest or control group subjects' performance. This result seems to be as true for procedures that take as little as five minutes as it is for those that have taken an hour. The use of fixed trials or trials to criterion procedures is somewhat determined by the researcher's assumptions about the trainability of conservation. Moreover, with the

exception of the social interaction techniques, no one type of training strategy, regardless of its theoretical inspiration, has been shown to be superior to any other.

It also seems to be a well-supported, but not surprising, principle in this literature that the training effort needed to bring a behavior to criterion is most successful with behaviors which were initially closest to the criterion. Using each researcher's criterion of success, 50 percent of 62 attempts to train 4-5 year olds succeeded while 70 percent of 60 attempts with 6-8 year olds succeeded. The evidence for aptitude treatment interactions in this literature, like all others, is scant, but there remains the theoretical issue of whether training is constrained by the child's developmental level. The Genevans (Inhelder, Sinclair, and Bovet, 1974) claim training is only successful with transitional children who give prior evidence of some conservation--either with a simpler concept, content, or transformation. Murray (1972) and Murray, Ames and Botvin (in press), however, have reported no significant differences in the training gains between nonconservers who had exhibited no pretest conservation and those who had exhibited some. Brainerd (in press) concluded that to date there is no compelling evidence that training is constrained by preoperational or transitional cognitive level in that each receives equal benefit from training.

It should be noted that many of these training strategies have face validity as classroom techniques and in many instances

would seem to be a teacher's first response to a child who thought, for example, that the number of objects in a patterned array changed when the pattern changed.

What follows is a formal description of the general training paradigm (Steps 1-6 below) and descriptions of eight primary varieties of training that have been researched and have direct classroom applicability.

Conservation Training Paradigm

It is established by virtue of some measurement procedure, however primitive (e.g., counting, weighing, hefting eyeballing, etc.) that

1. $Axy = Bxy$ Where A and B are identical objects with respect to at least two attributes, x and y; where x is the property in question, say weight, and y is some other property, say shape.

2. $Bxy \xrightarrow{ty} B^1xy^1$ Object B is transformed with respect to y into B^1 by a transformation (t) that is irrelevant with respect to x because it does not change x; it only changes y (ty). Relevant transformations (tx) change x as it is measured or indicated by the measurement procedure in 1 above. Some guarantee that the child was aware of the transformation should be provided in the procedure.

3. Conservation Questions (Q1): Is B^1xy^1 = or ≠ Axy?

(Q2): Why?

4. Training procedure (4.1-4.8 below).

5. Q1.

6. Any of the additional criteria (6.1-6.7) depending on the theoretical viewpoint of the experimenter may be employed:

6.1 Q2 may be asked.

6.2 Q1 and Q2 may be asked at a later time (day, week, month.

6.3 It may be suggested that $B^1xy^1 \gtrless$ Axy for various reasons (counter-suggestion).

6.4 Q1 and Q2 may be asked about different A's and B's with respect to x and with respect to some or different y's and ty's (specific transfer, i.e., the same conservations on different objects and by different transformations.

6.5 Q1 and Q2 may be asked about different x's and same or different y's and ty's (nonspecific transfer, i.e., different conservations).

6.6 Differently structured tasks may be assessed (seriation, transitivity, identity, classification, etc.).

6.7 Training procedure may be reinstated until Q1 answered correctly (trials to criterion).

It should be noted that Step 3 of the paradigm should not be answerable simply from an inspection or measurement of B^1 and A; if it is, discrimination and not conservation is assessed. The conservation judgment, $B^1xy^1 = Axy$, is not a judgment as much as it is a deduction based on four premises. Two of these are given explicitly in the experimental procedure, $Axy = Bxy$ and $Bxy \xrightarrow{tv} B^1xy^1$, and two must be supplied implicitly by the subject, viz. $B^1xy^1 = Bxy$ and a knowledge of transitivity (if $A = B$ and $B = B^1$, then $A = B^1$). This analysis of the paradigm reveals appropriate items for training, namely the underlying logical structure and the knowledge that $B^1xy^1 = Bxy$ although some procedures have focused upon the conclusion.

Incidentally, nonconservation can be a deduction, and in that sense, nonconservation represents a logical competence equal to that presumed for conservation. Nonconservation follows from the implicit premises, $B^1xy^1 \gtrless Bxy$ and "if $A = B$ $B \gtrless B^1$, then $A \gtrless B^1$." Murray and Armstrong (1976) have shown some nonconservers do, in fact, feel their judgments are necessary.

The analysis also reveals that the usual acceptable answers to Q2 are inadequate (e.g., Murray & Johnson, 1969) because they do not provide or represent any information that features in the conservation deduction. They do not provide transitivity or the knowledge that $B^1xy^1 = Bxy$.

Each training procedure may be viewed as implicitly focusing upon one or another aspect of the paradigm--its explicit and implicit premises and conclusion, although not every trainer has appreciated that the judgment itself is not the object of instruction, but rather deduction of the judgment from the premises.

The Training Procedure

Each procedure has a well-established pedagogical counterpart in the education literature and is based upon different assumptions about the nature of the child's competence and the causes of the nonconservation response at Step 3. To some extent they center upon whether the source of the error is presumed to be rooted in competence factors or performance factors and whether the error stems from insufficient information about one or another of each step of the paradigm. Operationally, the procedures are as follows:

4.1 Feedback (law of effect strategies to provide the conclusion $Axy = B^1xy^1$ to some extent obviate the deduction, although $Bxy = B^1xy^1$ may be provided.

4.11 Some measurement procedure applied to B^1xy^1 and Axy to demonstrate equality with Axy, or

4.12 $Axy = D^1xy^1$ validated by authority and reinforcement and "$Axy \neq B^1xy^1$" response simply punished or extinguished.

4.2 Cognitive conflict (an instance of reductio ad absurdum to provide $D^1xy^1 = Bxy$). Bxy simultaneously transformed (sometimes successively) by ty and tx

to $B^1x^1y^1$ such that the outcome with respect to x hopefully conflicts and is untenable. For example, a clay ball may be fattened with clay subtracted so that the transformed ball appears both heavier and lighter. If B^1xy^1 is taken as greater than Bxy and B^1xy^1 can be seen also as less than Bxy, this inconsistency requires resolution by the hypothesis that B^1xy^1 = Bxy. The likely outcomes are:

4.21 The conflict is ignored and ty and tx are taken as separate and independent events (i.e., ball was heavier, then lighter).

4.22 The conflict is maintained as a paradox or mystery.

4.23 The conflict is avoided by forced response (Q1) to authority of the experimenter.

4.24 ty is accepted as changing x and tx is rejected (nonconservation).

4.25 tx is accepted as changing x and ty is rejected (conservation).

4.3 Training by analogy or apperception (apparent-real discrimination to provide Axy = B^1xy^1 or break down correlation between x and y as an illusion. The particular procedure presupposes a prior distinction has been acquired to which the effects of tx and ty may be linked. In this case it is supposed

that a distinction between appearance and reality has been acquired and conservation is made an instance of this. It creates two questions for Q1: "Does Axy look heavier, etc. than B^1xy^1?" (Q_L) and "Is Axy really heavier, etc. than B^1xy^1?" (Q_I) and follows each with feedback (4.1) so that Q_L elicits $Axy \neq B^1xy^1$ and Q_I elicits $Axy = B^1xy^1$. Other appropriate analogies, metaphors, etc. could be used, but the procedure is hazardous because there are no necessary links between an event and its metaphor or analogy.

4.4 Cue reduction or shaping (screening to minimize or eliminate effects of ty). Child is prevented from concluding $B^1xy^1 \gtrless Axy$ by masking or screening the effects of ty or by performing ty slowly so that the initial response Axy = Bxy is preserved as long as possible; a slow motion strategy to preserve the initial equality. To some extent this procedure violates step 2 of the paradigm.

4.5 Discrimination training (to demonstrate x and y are independent; assign Q1 to x only). The independence of x and y is demonstrated by the measurement procedure for x used in Step 1 after tx and ty are performed on B as follows:

4.50 tx and no ty with the result that x changes ($Bxy \xrightarrow{tx} B^1xy^1$; B and B^1 measured).

4.51 no tx and ty with the result x does not change ($Bxy \xrightarrow{ty} B^1xy^1$; B and B^1 measured).

4.52 tx and ty with the result x changes ($Bxy \xrightarrow{txty} B^1x^1y^1$; B and B^1 measured).

4.53 no tx and no ty with the result x does not change ($Bxy \xrightarrow{0} Bxy$; B and B measured).

4.6 Verbal rule instruction (algorithmic learning at any step in paradigm). Child is given a rule, such as if no tx then no change in x (if nothing is added or subtracted, then nothing changes). Provides a verbal mediator for any other strategy as well. This is teaching by telling.

4.7 Theoretical prerequisites training. The prerequisites vary with the theory from Gagne empirical hierarchy analyses of every step of the paradigm to the abstract Genevan structures which provide the intellectual competence to make the deduction. For example,

4.71 Training on multiplication of classes and relations (the appropriate logical groupings).

4.72 Training on operativity features (e.g., reversibility by inversion $B^1xy^1 \xrightarrow{ty} Bxy$; reversibility by reciprocity or compensation, i.e., ty analyzed as having component effects, y_1 and y_2 where y_1 and $y_2 = y$. Change in shape in y is composed of change in height, y_1, and width, y_2. Effects of y_1 and y_2 conflict

(4.2) and can be coordinated with tx effects by (4.5) to provide an integrated understanding of covariation and independence of x and y.

4.73 Training on simpler conservation tasks, viz. identity forms, discontinuous materials, more primitive concepts, etc.

4.8 Social interaction, imitation, cognitive dissonance role playing (provides $Axy = B^1xy^1$ to guarantee conflict with $Axy \neq B^1xy^1$). Nonconservers must come to a group agreement with conservers, must imitate conservers, and/or must role play as a conserver. A distinction is presumed between information derived personally from actions on the world and information we derive from or in acquiesence to other minds.

While some of these strategies in some theories have superiority over others and some have pedagogical superiority in certain educational philosophies (e.g., discovery versus telling), there is no compelling empirical superiority of any except class 4.8 which lead to very high response levels in all subjects. This only suggests that confirmation of one's beliefs by another mind may be a critical feature of intellectual development since 4.8 may include all the features of the other procedures.

These instructional strategies are presented in this abstract notation to demonstrate their applicability to any

concept as well as to set forth the structure of variations that does exist in the various conservation training attempts.

The recommendations for instructional design are that every curricular concept be analyzed as a conservation concept into its relevant and irrelevant attributes. The source of the relevant attributes is the academic discipline in which the concept resides. The source of the interesting irrelevant attributes, namely those which are confused with relevant attributes, is developmental cognitive psychology. The conservation paradigm provides a diagnostic device for assessing understanding by probing the pupil's discrimination of the relevant from irrelevant attributes and of his appreciation of the necessity of the relationships. The training strategies are evaluated procedures for providing information and/or competence for segregating and integrating the relevant and irrelevant attributes. At present each appears to be a sufficient but not necessary device for instruction and conceptual development.

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